Evaluation of Alignment Methods for Transtibial Prostheses

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Masters Research Presentation

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Intro: Developing Countries

- 3-4 million people in need of a prosthesis (Murdoch 1990)
- <5% people have access to medical care (WHO, 2003)
  - 80% in remote, rural areas (Sethi, 1989)
  - Unaffordable
  - Few trained specialists

Intro: Monolimb Appropriate Technology

- Fewer components
- Affordable
- Durable
- Delivered on initial fit (Valenti 2001)
- >1,000 fittings
  - Burma, Thailand, China, Vietnam, El Salvador

Monolimb initial fit, Burma 2007

Intro: Prosthetic Alignment

Modular Design

Bench Alignment

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Static Alignment

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Dynamic Alignment

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Delivery of Definitive Prosthesis

Monolimb

Bench Alignment

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Monolimb fabrication, Thailand 2007

Intro: Appropriate Alignment

"...good alignment can be achieved on the basis of [patient] measurements, if an easy procedure and fabrication fixture can be developed to assist with alignment..." CIR 2007

Two Alignment Methods: **VAA, ABA**

Research Goal

Question: Which alignment method (VAA, ABA, TRAD) requires the least magnitude of alignment changes to result in optimal gait?

Hypothesis: An alignment method based on patient measurements (VAA, ABA) will require a **lower magnitude of change** to arrive at appropriate prosthetic alignment.

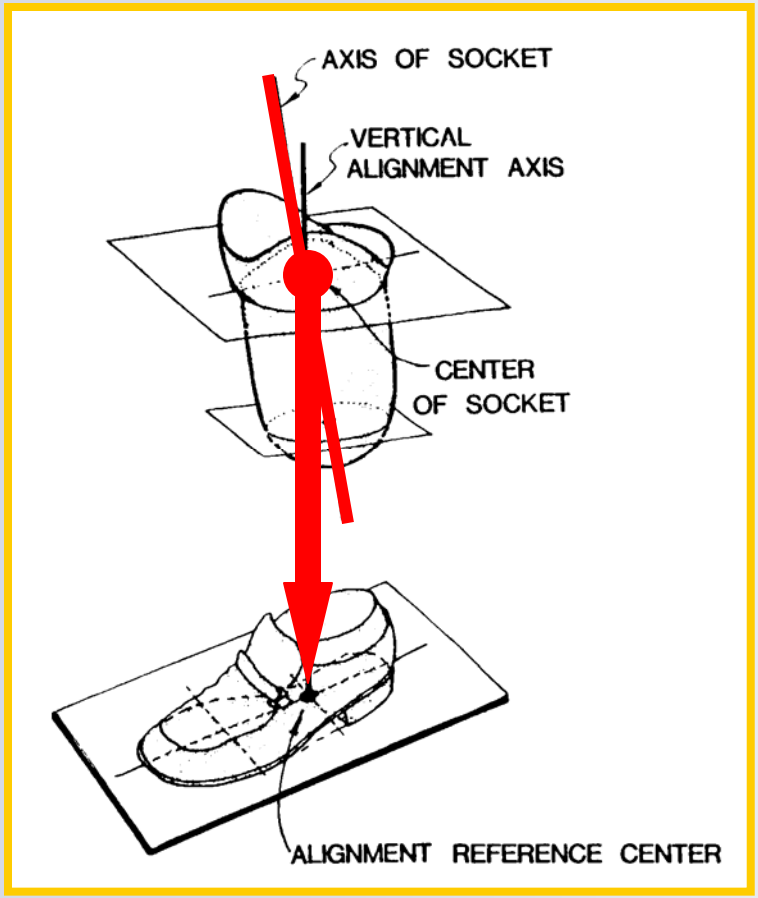
Methods: Subjects

- 8 transtibial amputees
  - 18-65yo, <220lbs, healthy
- 8 students of prosthetics
  - Georgia Tech, MSPO
  - NUPOC
- 2 prosthetists per amputee/student pair

Protocol: Alignment Capture

1. Student captures VAA, ABA alignments on amputee

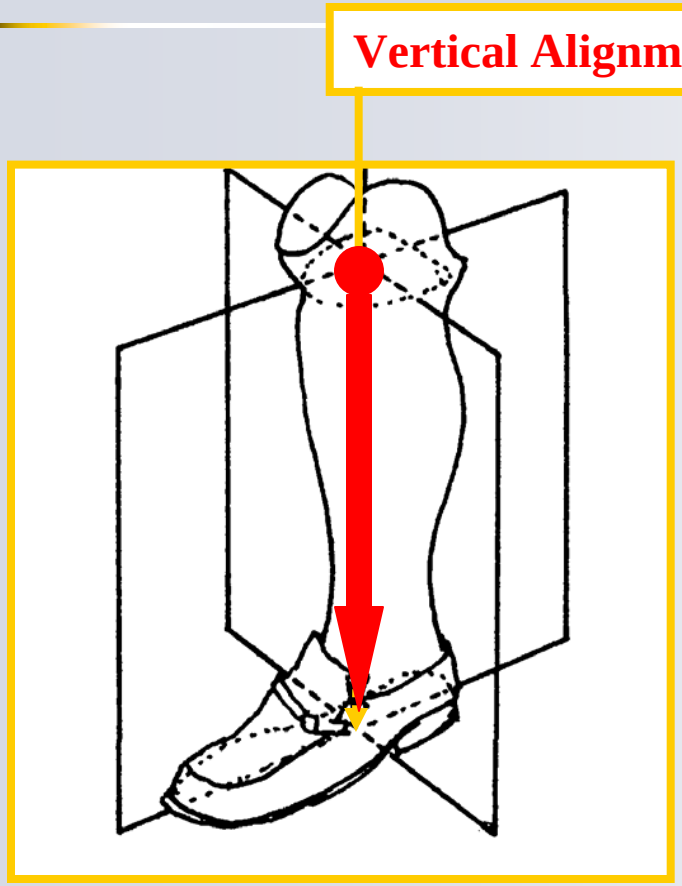
Vertical Alignment Axis (VAA)



Wu et al, 1981

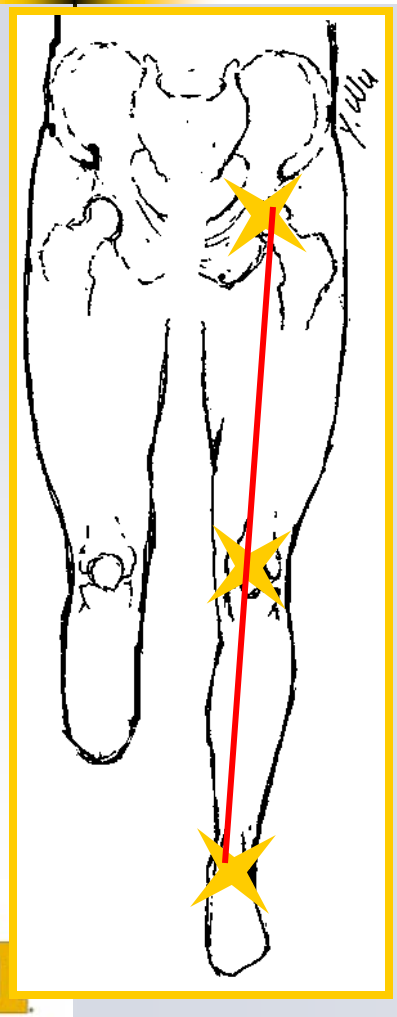
- Socket center at PTB level projects onto alignment reference center
- Socket angles determined by natural attitude of limb during weight bearing

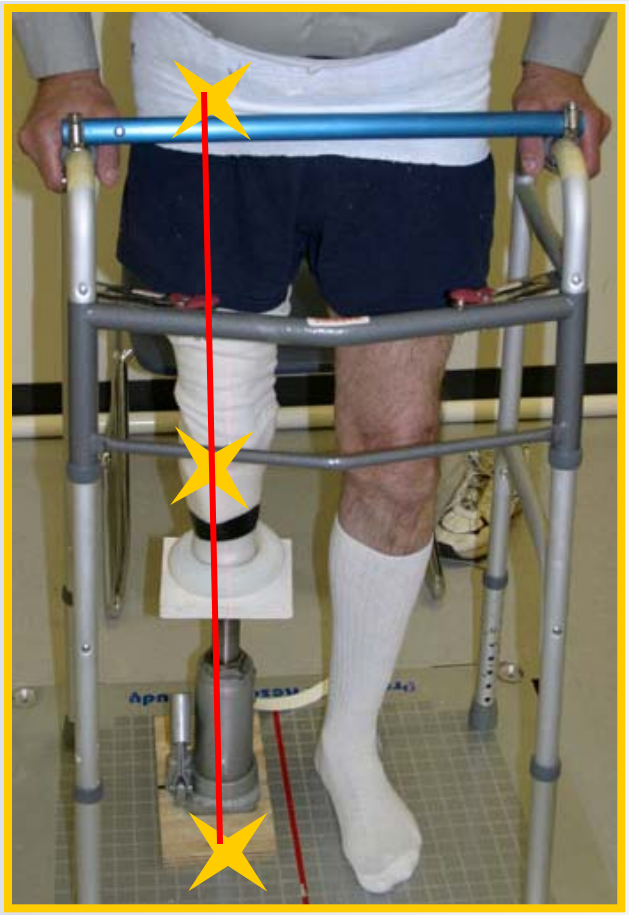
Vertical Alignment Axis (VAA)



- Coronal and sagittal planes intersection

Anatomical Based Alignment (ABA)





- Hip, knee, and ankle joint centers lie along a common axis in frontal and sagittal planes.

Protocol: Assemble and Dynamically Align

2. Students assemble 3 prostheses
   - VAA, ABA, TRAD
- Quantify bench alignments

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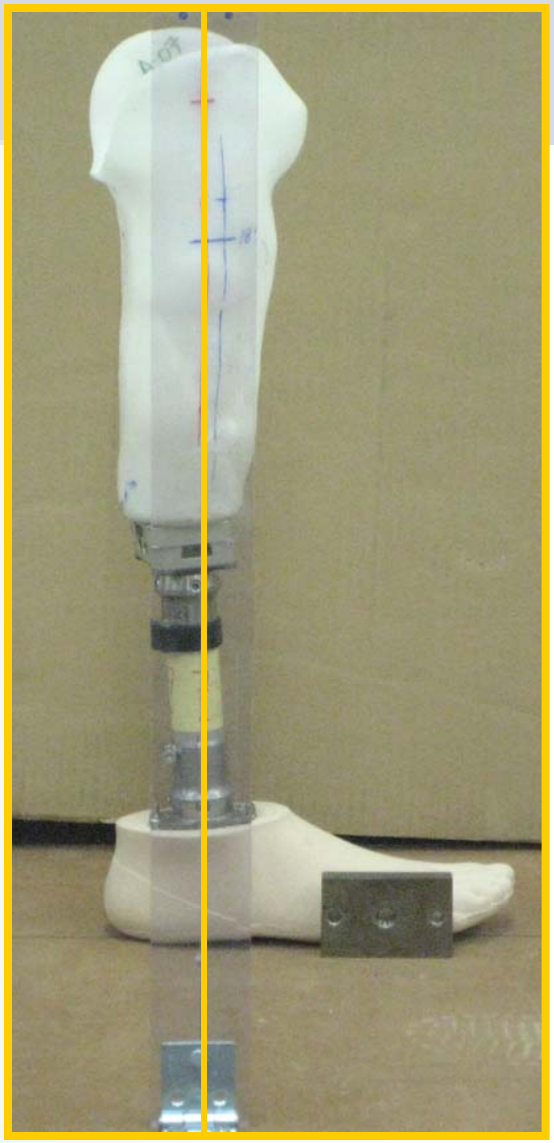
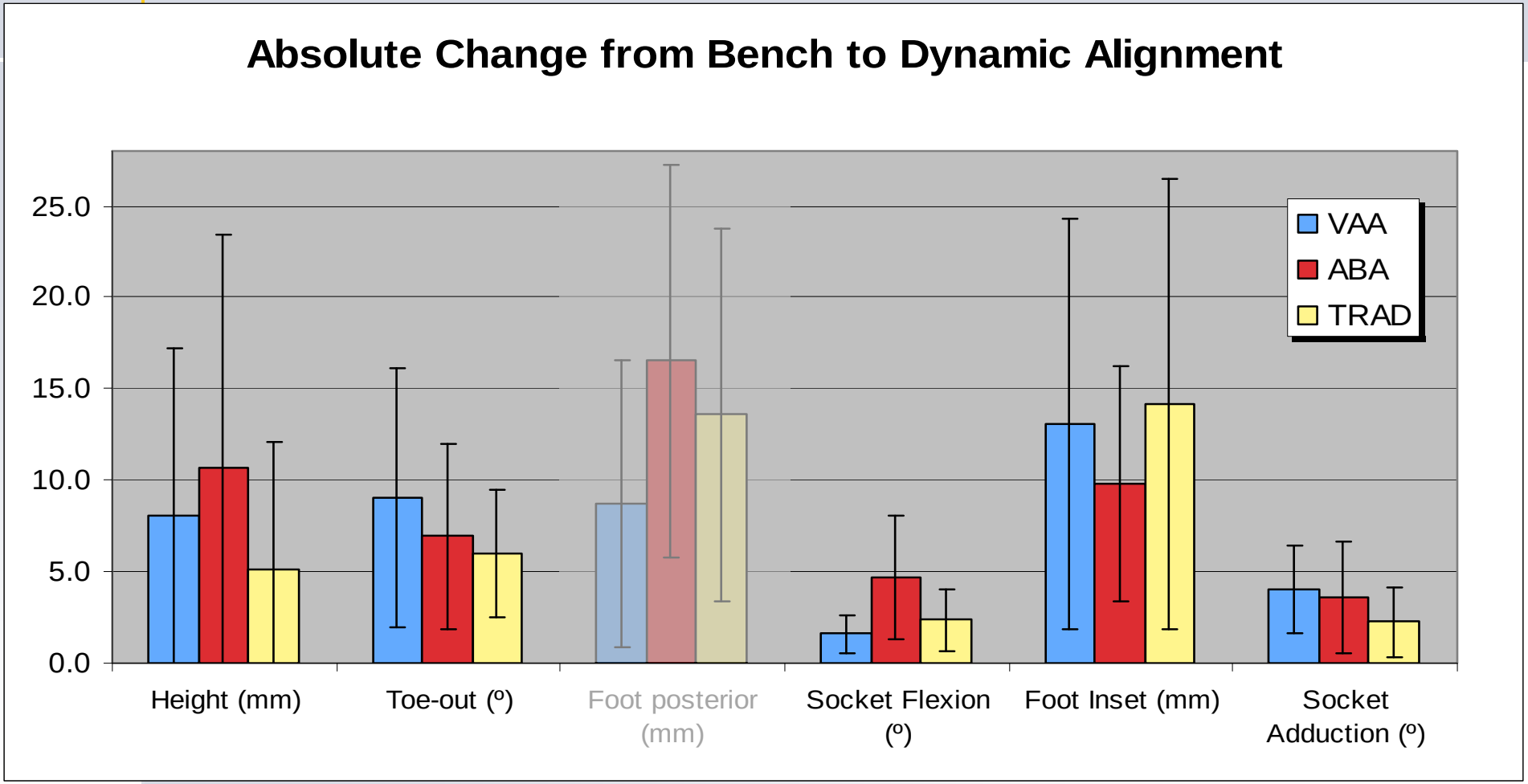
3. Prosthetists dynamically align 3 prostheses
- Quantify dynamic alignments



Data

Alignment Parameters
Quantitative
1. Height
2. Toe-out
3. Foot posterior
4. Socket flexion
5. Foot inset
6. Socket adduction

Results

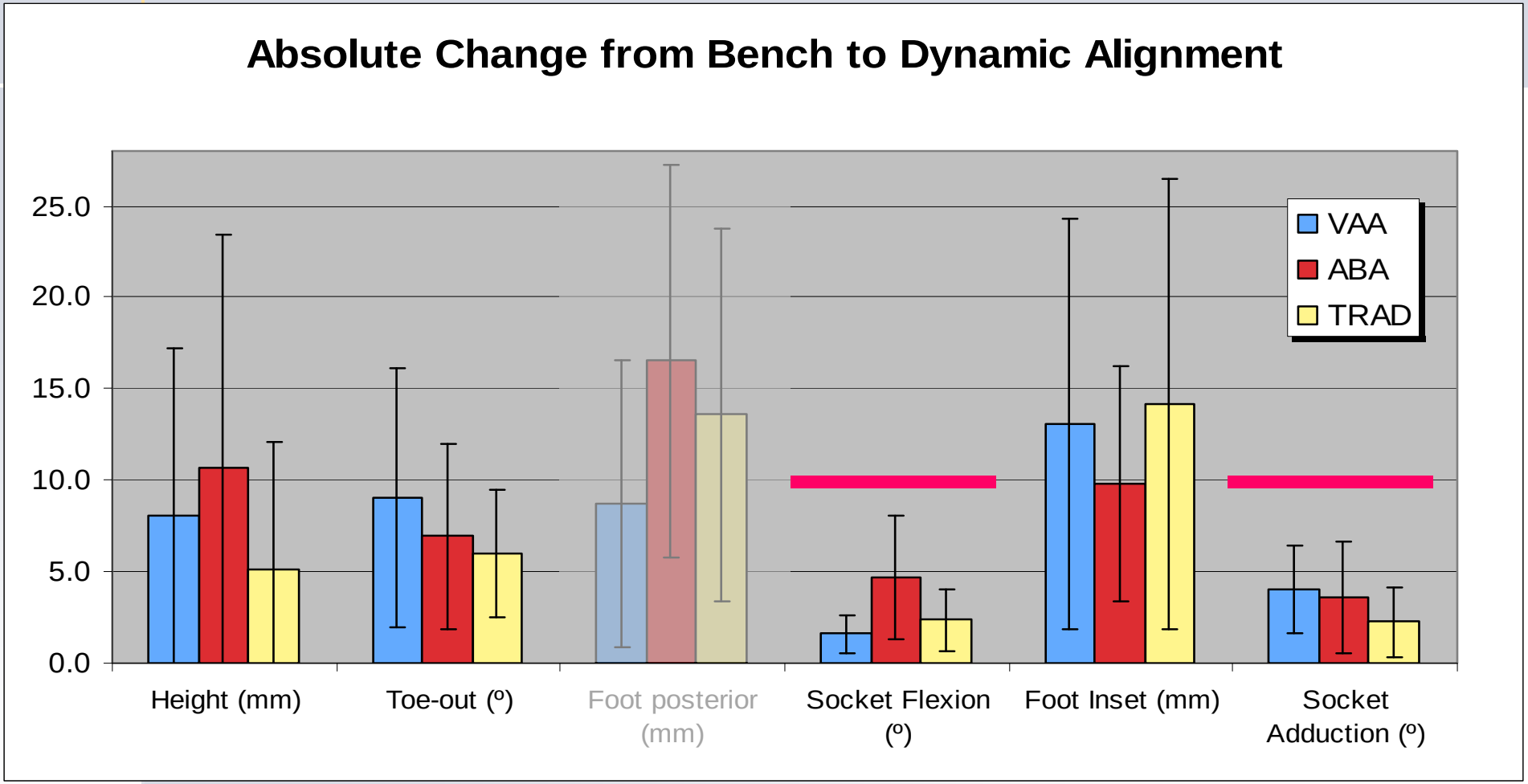


- No statistical significance ($p<0.05$) by repeated measures analysis

Discussion: Zahedi et al, 1986

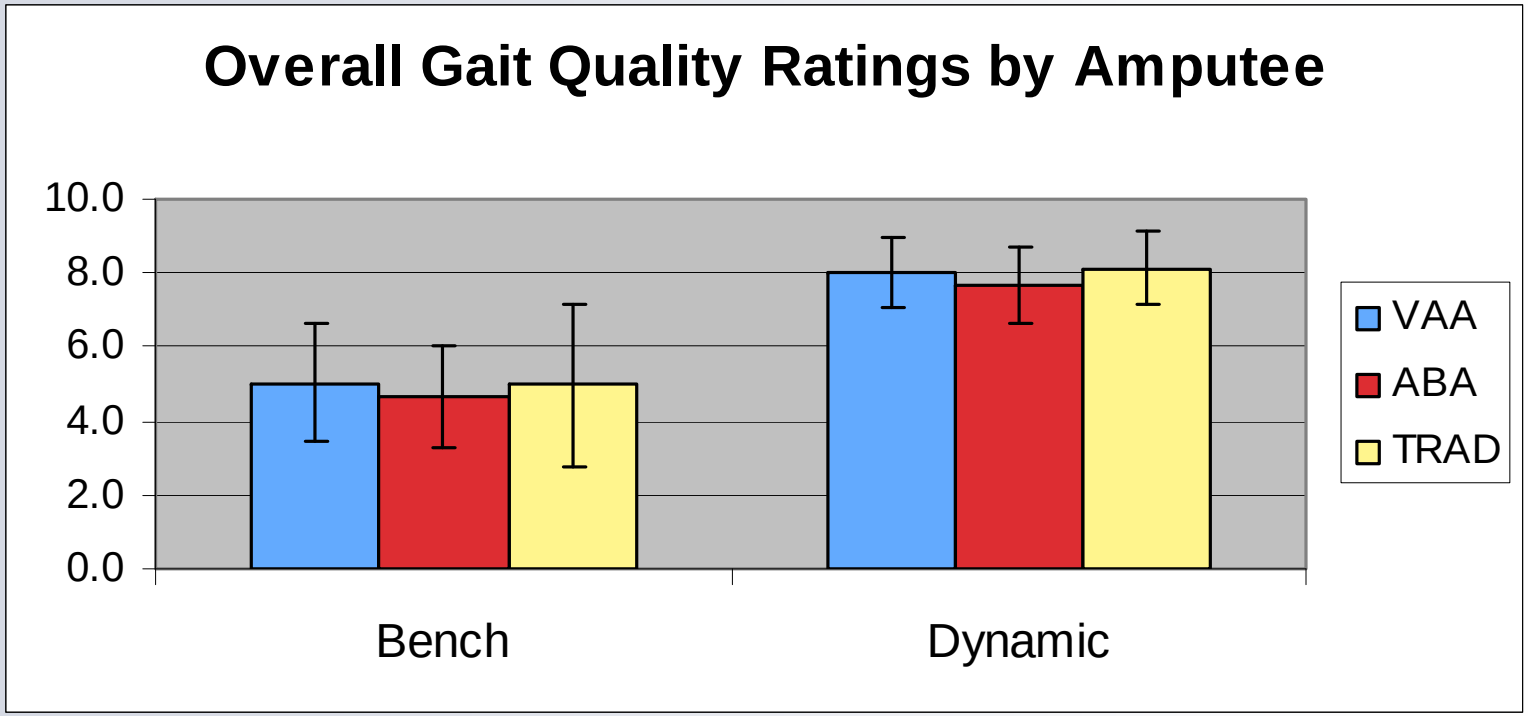
- Alignment of Lower Limb Prostheses
  - A wide range of alignments are considered acceptable by the amputee and prosthetist
  - Average acceptable ranges
    - 45mm socket shifts
    - 10º socket tilts
  - Values depend on patient activity level and level of amputation

Discussion



- Where these magnitudes of change of any significance to the amputee?

Discussion: Amputee Subjective Feedback

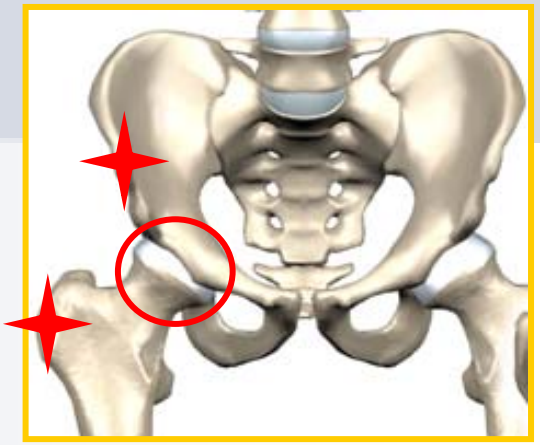


Conclusion

Hypothesis: An alignment method based on patient measurements (VAA, ABA) will require a lower magnitude of change to arrive at appropriate prosthetic alignment.

NOT SUPPORTED

Limitations



- Soft heel of SACH foot
- Student inexperience
- ABA
  - Difficulty palpating anatomy
  - Does surface anatomy correspond to joint centers?
- VAA and ABA
  - Base of support assumed “fist-width apart”

Future Directions

- Control student, vary amputees

  Test accuracy of alignment methods

-or-

- Control amputees, vary student

  Test if little training is necessary

-or-

- Control student, vary amputee BMI

  Test effects of body composition

References

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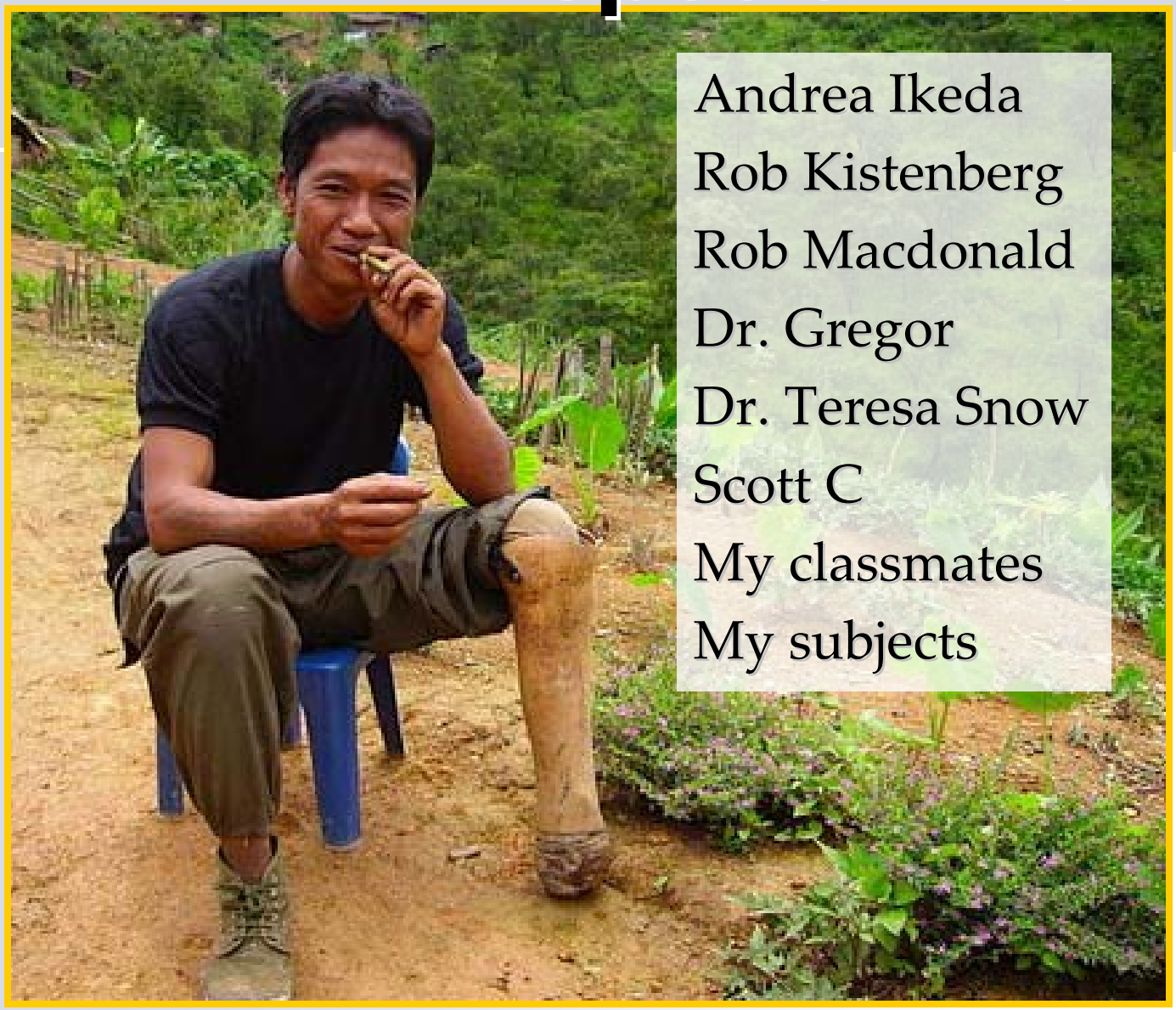
- Wu Y, Crncick MD, Krick HJ, Putnam TD, Stratigos JS. Scotchcast PVC interim prosthesis for below-knee amputees. *Bulletin of Prosthetics Research* 1981;fall:40-45.
- Zahedi MS, Spence WD, Solomonidis SE, Paul JP. Alignment of lower-limb prostheses. *J Rehab Research* 1986;23(2):2-19.

* Photographs courtesy of Jody Riggs, BCIT ’08. Burma-Thailand 2007.

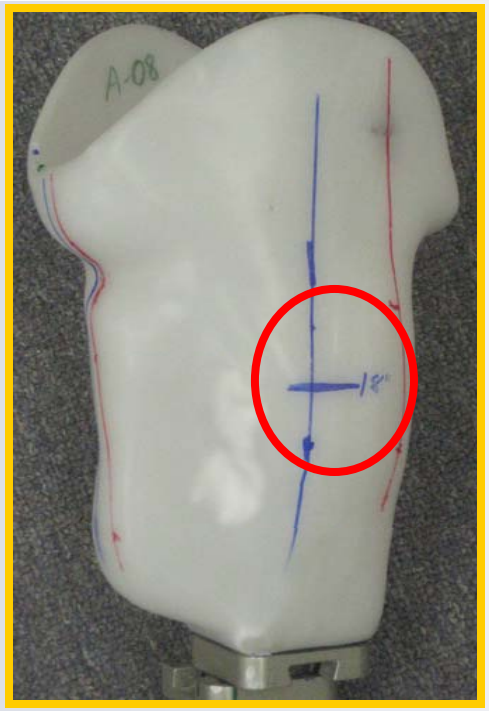
Special Thanks

Monolimb Recipient, Burma 2007



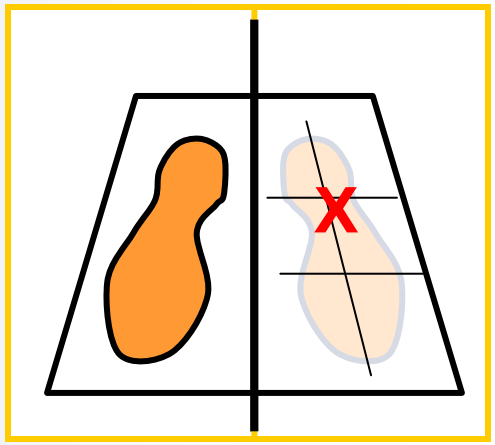
Methods

Height, ABA



Height, VAA

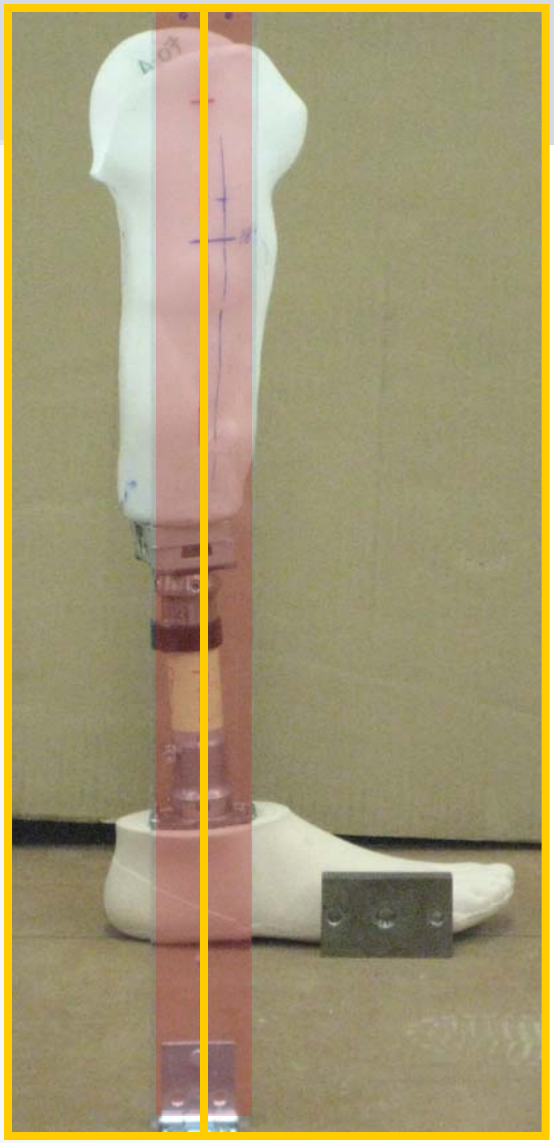
Alignment Board



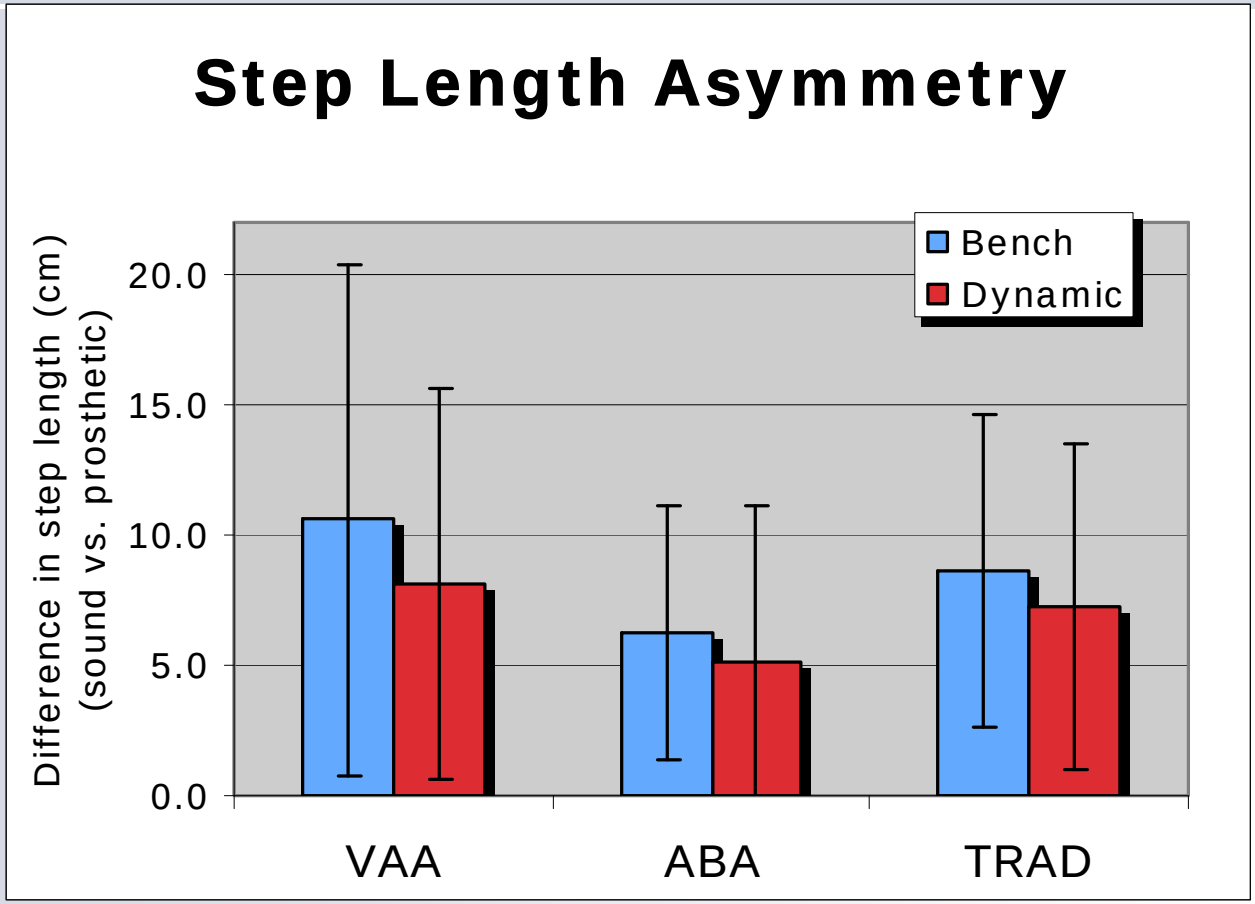
Toe out, VAA

Alignment Board

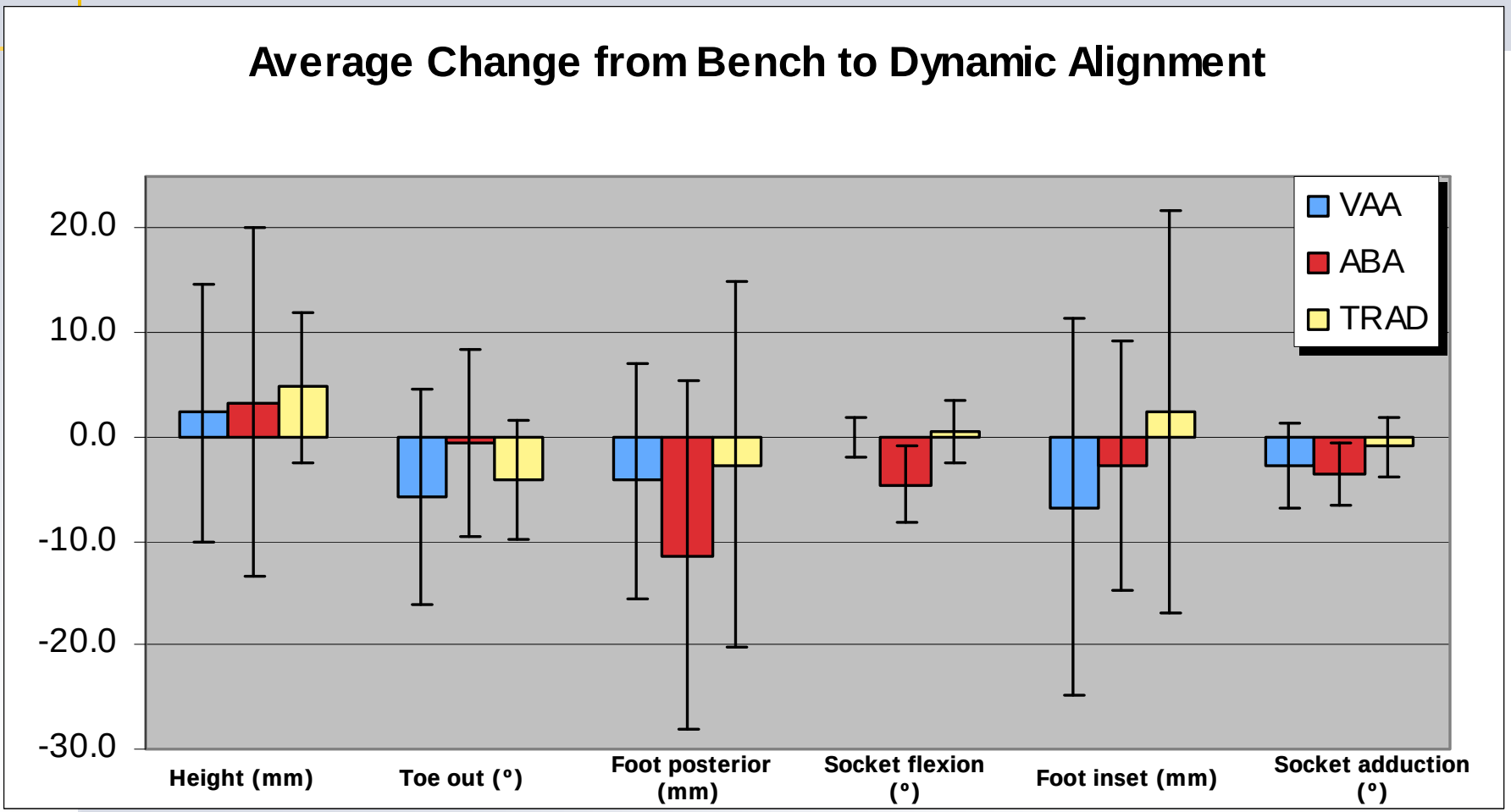
- Align 3 things:
  - Etched line on plexiglass
  - Marker line on board
  - Marker alignment line on socket



Step Asymmetry



Averaged Results



Monolimb Recipients